ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5398

Formulas for calculation of sea water salinity using a successive scheme

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Original title: Unknown

In: Marine Hydrophysical Research 3(70): 152-166, 1975

Original language: Russian

Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1988

15 typescript pages

ABSTRACT

The concrete values and formulas are given for certain links of a successive scheme of calculation of salinity. As is shown, a limiting error of the proposed method is equal to 0.009 - 0.014 $^{\circ}/_{\circ\circ}$ for real conditions of the World Ocean and is mainly due to inaccuracies of published results of experimental studies of a relation between electric specific conductivity - temperature - pressure - salinity.

Introduction

In this article concrete values and formulae are developed for each section of a progressive scheme for salinity calculation. It is shown that the maximum error in the proposed method is .009 - 0.014 °/₀₀ for the natural range of values encountered in the world ocean and that this results from variations in the experimental relationship between specific electroconductivity - temperature - pressure - salinity as published in the literature.

In Table 1 are given the constants and formulae which come into the scheme we propose for calculating salinity. We will deal in more detail with each of them and will examine the material basis from which they are derived.

Specific Electroconductivity of Normal Waters with Salinity of Exactly 35 °/₀₀

The average value of specific electroconductivity of Copenhagen normal water is $42{,}918 \times 10^{-3}$ (International ohms)$^{-1}\cdot$cm^{-1}. This value is arrived at by a statistical analysis of the stability of the chlorinity - salinity - electroconductivity relationship of normal water, by Park (9), results of the measurement of specific electroconductivity of normal water series P-37, by Reeburgh (11), and the statistical analysis of Knowles (8). The RMS error of the average value of $X_{35,15,0}$ found for all Copenhagen normal water, is 0,001 millimhos/cm and the overall error in terms of the standard used by Jones (7, 11) is ± 0,005 millimhos/cm. Such an error in electroconductivity leads to a salinity error of 0,005 °/₀₀.

The temperature dependence of the specific electroconductivity of normal water $f(t)_{48}$ (the subscript refers to the International Practical Temperature Scale, 1948) is derived from a detailed comparison of $f(t)^{B-A}_{48}$, obtained by Brown and Allentoft (4) with $f(t)^{R-K}_{48}$ calculated from the data of Reeburgh (11) by Knowles (8). In spite of the equal accuracies quoted for these measurements, the discrepancy between $f(t)_{48}$ values in the temperature range -1 to +3°C exceed the differences permitted for them, ($\pm 10\cdot10^{-5}$), where $f(t)^{B-A} < f(t)^{R-K}$ for normal water series P-37, P-39, and also for the water of the Red Sea.

The research of Dauphinée summarized in ref. (10) discovered a discrepancy between salinities calculated from the formulas of Ribe and Howe (12) compared to real values (reaching +0.025 °/₀₀) for S=30 to 35 °/₀₀,

t = -2° to +1°C, Ribe and Howe (12) expressed temperature dependency f(t) using the results of Brown and Allentoft (4). When S = 35 °/₀₀ (correction Δ_{15} = 0) then the whole error can be defined in reference to the expression of $f(t)^{B-A}$ in this range of temperature where the underestimated value f(t) leads to too high a calculated salinity, as given by the researches of Dauphinée. Application of the correction of Dauphinée helped to reconcile the functions $f(t)^{B-A}_{48}$ and $f(t)^{R-K}_{48}$, but the remaining discrepancy $\Delta f(t) \leq 20 \cdot 10^{-5}$ still exceeds the value permitted for error in the range of temperatures -1 to +3°C.

In the absence of other measures of temperature dependency, expression $f(t)_{48}$ is defined by us as the average of the results of Dauphinée and Reeburgh-Knowles for temperature range -2 to +1°C and average value of Brown and Allentoft, and Reeburgh-Knowles for temperature range 1 to 31°C. From the data of Reeburgh-Knowles the temperature dependencies of normal water series P-37, P-39 and the water of the Red Sea were used at a chlorinity of 19,369 °/₀₀. By our calculations, the maximum discrepancy obtained in this way for f(t) from true values does not exceed $\pm 5 \cdot 10^{-5}$ for t = 4 to 23°C and $\pm 14 \cdot 10^{-5}$ for t = -2 to 4°C and t = 23 to 31°C. In terms of salinity this corresponds to ± 0,002, and ± 0,008 °/₀₀ respectively.

The dependency of electroconductivity of normal waters on hydrostatic pressure Y(p) was researched by Bradshaw and Schleicher (3), and in Table 1 are given the expressions Y(p) recommended by the quthors. The RMS deviation of the calculated values Y(p) expressed as an equivalent salinity is 0,002 °/₀₀, and the maximum deviation does not exceed ± 0,005 °/₀₀.

Expression $Y_2(p)$ and $Y_3(p)$ are derived by the authors of the present article on the basis of simplification of expression $Y_1(p)$ for pressure ranges 0 - 6000 and 0 - 3000 dbar respectively. For real values of temperature and pressure encountered in the ocean, the maximum discrepancies of value $Y_2(p)$ and $Y_3(p)$ from $Y_1(p)$ do not exceed $\pm 14 \cdot 10^{-5}$, that is an equivalent salinity of ± 0,006 °/₀₀.

Correction $\Delta_p = R_{s,t,0} - R_{s,t,p}$

The corrections Δ^1_p and Δ^2_p shown in Table 1 are derived on the basis of research in reference (3) and may be used in ranges of pressure 0 - 10000 and 0 - 2000 dbar respectively. Maximum values of calculated and experimental values of $\delta\Delta^1_p$ and $\delta\Delta^2_p$ do not exceed $\pm 12 \cdot 10^{-5}$, or a salinity equivalent of

± 0,005 °/₀₀

Correction $\Delta_{15} = R_{s,15,0} - R_{s,t,0}$

At the present time two formulae are important for calculating the correction Δ_{15}: Δ_{15}^{C} of Cox et. al. (5), recommended in the Internal Oceanol. Tables (2) for the temperature range 10 to 31°C and the formula Δ_{15}^{B} given in Brown (6) for ranges of temperature 0 to 30°C, shown in Table 1. To check these two formulae we will compare them with the results of research by Brown and Allentoft (4) and Reeburgh (11). To arrive at Reeburgh's temperature correction it is essential to calculate the following value:

$$\Delta_{15} = X_{C\ell,15,0}/X_{\text{interp.},15,0} - X_{C\ell,t,0}/X_{\text{interp.},t,0}$$

where $X_{C\ell,t,c,}$ and $X_{C\ell,15,0}$ - specific electroconductivity of Red Seawaters with chlorinity Cℓ, at temperatures t and 15°C respectively at atmospheric pressure; $X_{\text{interp.},t,0}$ and $X_{\text{interp.},15,0}$ -specific electroconductivity of this water with chlorinity 19,369 °/₀₀ at temperature t and 15°C respectively at atmospheric pressure.

To diminish dependence on random errors, Δ_{15}^{P} was somewhat smoothed out. The value Δ_{15}^{P} at temperature -2°C was derived by way of graphic extrapolation. In Tables 2 & 3 are shown the values of temperature corrections Δ_{15}^{C} and Δ_{15}^{B}. It is noted that the correction of Cox corresponds well with experimental data only in the area of temperatures 15 - 30°C, where maximum divergences, $\delta\Delta_{15}^{C}$, are not greater than $(-5 \text{ to } +12)\cdot 10^{-5}$ in comparison with Brown and Allentoft's data and $\delta\Delta_{15}^{C} = \pm 4\cdot 10^{-5}$ in comparison with Reeburgh's experiment. In the low temperature range -2 to 10°C, Cox's correction diverges significantly from experimental data and discrepancies reach $75\cdot 10^{-5}$, which is a salinity equivalent of 0,03 °/₀₀. The correction calculated from Brown's formula satisfactorily agrees with all experimental data in the area of temperatures -2 to 29°C, with a maximum discrepancy not greater than $\delta\Delta_{15}^{B} = \pm 13\cdot 10^{-5}$ in ranges of conductivity ratios $R_{s,15,0} = 0.1$ to 1.13, a salinity equivalent of ± 0,005 °/₀₀.

From the results of research in references (4, 5, 11) the authors of this article have worked out the two new expressions for temperature correction given in Table 1 as formulae Δ_{15}^{1} and Δ_{15}^{2}. Both formulae may be used for temperature ranges -2 to 30°C, but Δ_{15}^{1} is earmarked for calculation in wide range of salinity (3 - 42 °/₀₀), and Δ_{15}^{2} for use in a narrow range

TABLE 1

Constants & Formulas for Calculating
Salinity of Sea Water

Values and Functions	Dimensions and Scales		Ranges of Validity of Values or Formulas		
	Specific Electroconductivity	Temp. °C	Salinity °/₀₀	Temp. °C	Hydrostatic Pressure dbar
$X_{35,15,0}$					
$42.918 \cdot 10^{-3}$	(Int. Ohm)$^{-1}$cm^{-1}	IPTS-48	35.000	15.00	0
$42.924 \cdot 10^{-3}$	(Int. Ohm)$^{-1}$cm^{-1}	IPTS-68	35.000	15.00	0
$42.896 \cdot 10^{-3}$	(abs. Ohm)$^{-1}$cm^{-1}	IPTS-48	35.000	15.00	0
$42.902 \cdot 10^{-3}$	(abs. Ohm)$^{-1}$cm^{-1}	IPTS-68	35.000	15.00	0
4.2896	mho m^{-1}	IPTS-48	35.000	15.00	0
4.2902	mho m^{-1}	IPTS-68	35.000	15.00	0
f(t)					
$f(t)_{48} = 0.676747 + 0.0200567 \cdot t_{48} + 1.089557 \cdot 10^{-4} \cdot t_{48}^2 - 0.624942 \cdot 10^{-6} \cdot t_{48}^3$		IPTS-48	35.0±0.02	-2to+30	0
$f(t)_{68} = 0.67666 + .0200617 \cdot t_{68} + 1.09035 \cdot 10^{-4} \cdot t_{68}^2 - 0.628232 \cdot 10^{-6} \cdot t_{68}^3$		IPTS-68	35.0±0.02	-2to+30	0
y(p)					
$y_1(p) = 1.0 + 0.01\ [g(t) \cdot f(p) + h(p) \cdot j(t)]$		IPTS-48	35.0±0.02	-2to+25	0 - 10000
$g(t) = 1.5192 - 4.5302 \times 10^{-2} t + 8.3089 \times 10^{-4} t^2 - 7.900 \times 10^{-6} t^3$		IPTS-68			
$f(p) = 1.04200 \times 10^{-3} p - 3.3913 \times 10^{-8} p^2 + 3.300 \times 10^{-13} p^3$					
$h(p) = 4 \times 10^{-4} + 2.577 \times 10^{-5} p - 2.492 \times 10^{-9} p^2$					

(cont'd)

(cont'd) - 2

$j(t) = 1.000 - 1.535 \times 10^{-1}t + 8.276 \times 10^{-3}t^2 - 1.657 \times 10^{-4}t^3$ $1(t) = 6.950 \times 10^{-3} - 7.6 \times 10^{-5}t,$ $m(S) = 35.00 - S$					
$Y_2(p) = 1.0 + (1.60228 \cdot 10^{-5} \cdot p - 5.0042 \cdot 10^{-10} \cdot p^2) \cdot (1.0 - 3.1813 \cdot 10^{-2} \cdot t + 6.94 \cdot 10^{-4} \cdot t^2 - 8.7 \cdot 10^{-6} t^3)$		IPTS-48 IPTS-68	35.0±0.02	-2to+25 -2to+15	0 - 1000 0 - 3000
$Y_3(p) = 0.9992 + (1.60228 \cdot 10^{-5} \cdot p - 5.0042 \cdot 10^{-10} \cdot p^2) \cdot (1.0 - 2.9713 \cdot 10^{-2} \cdot t + 4.34 \cdot 10^{-4} \cdot t^2)$		IPTS-48 IPTS-68	35.0±0.02	-2to+25 -2to+15 -2to+10	0 - 1000 0 - 5000 0 - 6000
Δ_p $\Delta_p^1 = -10^{-4} \cdot (1 - R_{s,t,p}) \cdot (0.0427 \cdot p - 1.5 \cdot 10^{-6} \cdot p^2) \cdot (1 - 0.03876 \cdot t + 0.0006122 \cdot t^2)$		IPTS-48 IPTS-68	30-40	-2to+25	0 - 10000
$\Delta_p^2 = -10^{-4} \cdot (1 - R_{s,t,p}) \cdot 0.0412 \cdot p \cdot (1 - 0.03876 \cdot t + 0.0006122 \cdot t^2)$		IPTS-48 IPTS-68	30-40	-2to+25	0 - 2000
Δ_{15} $\Delta C_{15} = 10^{-5} \cdot R_{s,t,0} (R_{s,t,0} - 1) \cdot (t - 15)$ [96.7 - 72.0 $R_{s,t,0}$ + 37.3 $R_{s,t,0}^2$ - (.63 + 0.21 $R_{s,t,0}^2$) $\cdot$ (t - 15)]		IPTS-48 IPTS-68	3 - 42	+10to+31	
$\Delta_{15}^B = (R_{s,t,0} - 1) \cdot (0.0175 \cdot R_{s,t,0} - 0.0045 \cdot R_{s,t,0}^2) \times (-1 + 0.08 \cdot t - 8.9 \cdot 10^{-4} \cdot t^2)$		IPTS-48 IPTS-68	3 - 42	-2to+29	
$\Delta_{15}^1 = 10^{-5} \cdot R_{s,t,0} \cdot R_{s,t,0} - 1) \cdot (t - 15) \cdot \{103.7 - 86.6 R_{s,t,0} + 73.3 \cdot R_{s,t,0}^2 - 24.0 \cdot R_{s,t,0}^3 - [.63 + .21 \cdot R_{s,t,0}^2 + 0.63 \cdot f(R_{s,t,0}) \cdot (t - 15)] + .0244 \cdot f(R_{s,t,0}) \cdot (t - 15)^2\}$ Where $f(R_{s,t,0}) = 1.17 - 2.435 \cdot R_{s,t,0} + 6 R_{s,t,0}^2$		IPTS-48 IPTS-68	3 - 42	-2to+30	
$\Delta_{15}^2 = 10^{-5} \cdot R_{s,t,0} \cdot (t - 15) \cdot (R_{s,t,0} - 1) \cdot]133.1 - 2.581 \cdot t - R_{s,t,0} \cdot (46.18 - 1.36 \cdot t)]$		IPTS-48 IPTS-68	30-40	-2to+30	

(Cont'd) - 3

$f(R_{S,15,0})$ $S_C = -0.08996 + 28.2972 \cdot R_{S,15,0} + 12.80832 \cdot R^2_{S,15,0} - 10.678969\ R^3_{S,15,0} + 5.98624 \cdot R^4_{S,15,0} - 1.32311 \cdot R^5_{S,15,0}$			3 - 42	+15.00	
$S_1 = -0.76507 + 32.317 \cdot R_{S,15,0} + 3.448 \cdot R_{S,15,0}$			17 - 42	+15.00	
$S_2 = -4.2044 + 39.209\ R_{S,15'0}$			33 - 37	+15.00	
$S_3 = -0.3546 + 30.7379 \cdot R_{S,15,0} + 4.9622 \cdot R^2_{S,15'0}$			7 - 18	+15.00	
$S_B = -0.2189 + 29.81964 \cdot R_{S,15'0} + 7.95554 \cdot R_{S,15'0} - 3.88602 \cdot R^3_{S,15,0} + 1.56530 \cdot R^4_{S,15,0} - 0.23469 \cdot R^5_{S,15,0}$			3 - 42	+15.00	

TABLE 2

Comparison of Corrections $\Delta^{B}_{15} \cdot 10^5$ and $\Delta^{C}_{15} \cdot 10^5$
With Experimental Results of Brown & Allentoft ($\Delta^{B-A}_{15} \cdot 10^5$)

Conductivity Ratio	Compared Values	Temperature °C								
		-2.0	-1.0	0.0	5.0	10.0	15.0	20.0	25.0	30.0
0.06853	Δ^{B-A}_{15}			117	74	35	0	-31	-58	-83
	Δ^{B}_{15}	128	119	110	68	32	0	-27	-50	-66
	Δ^{C}_{15}	111	103	102	62	26	0	-28	-54	-79
0.14134	Δ^{B-A}_{15}			210	131	60	0	-51	-98	-138
	Δ^{B}_{15}	238	223	204	127	59	0	-50	-92	-122
	Δ^{C}_{15}	202	189	175	113	52	0	-51	-98	-141
0.31511	Δ^{B-A}_{15}			342	208	94	0	-82	-151	-215
	Δ^{B}_{15}	404	374	346	215	100	0	-84	-155	-207
	Δ^{C}_{15}	326	304	287	182	88	0	-80	-154	-220
0.47696	Δ^{B-A}_{15}			375	235	108	0	-86	-162	-226
	Δ^{B}_{15}	442	412	380	236	110	0	-93	-171	-228
	Δ^{C}_{15}	350	327	303	194	93	0	-84	-160	-227
0.61142	Δ^{B-A}_{15}			346	214	97	0	-79	-148	-208
	Δ^{B}_{15}	416	386	357	222	103	0	-87	-160	-214
	Δ^{C}_{15}	318	293	276	175	84	0	-75	-142	-200
0.74763	Δ^{B-A}_{15}			274	169	79	0	-62	-116	-161
	Δ^{B}_{15}	310	288	266	167	77	0	-65	-120	-160
	Δ^{C}_{15}	248	231	213	135	64	0	-57	-107	-149
0.87611	Δ^{B-A}_{15}			153	99	44	0	-36	-66	-88
	Δ^{B}_{15}	171	159	147	92	43	0	-32	-59	-83
	Δ^{C}_{15}	141	131	121	76	36	0	-30	-58	-84
1.00000	Δ^{B-A}_{15}	0	0	0	0	0	0	0	0	0
	Δ^{B}_{15}	0	0	0	0	0	0	0	0	0
	Δ^{C}_{15}	0	0	0	0	0	0	0	0	0
1.13120	Δ^{B-A}_{15}			-177	-114	-56	0	+49	+85	+110
	Δ^{B}_{15}	-213	-198	-183	-114	-53	0	+45	+82	+110
	Δ^{C}_{15}	-197	-184	-170	-107	-50	0	+43	+80	+110

TABLE 3

Comparison of Corrections $\Delta^{B}_{15} \cdot 10^5$ and $\Delta^{C}_{15} \cdot 10^5$
With Experimental Results of Reeburgh ($\Delta^{R}_{15} \cdot 10^5$)

Conductivity Ratio	Compared Values	Temperature °C									
		-2.0	-1.0	0.0	5.0	9.0	15.0	19.0	25.0	29.0	30.0
0.842	Δ^{R}_{15}	(227)	+212	197	112	62	0.0	-30	-72	-98	-102
	Δ^{B}_{15}	223	207	192	119	67	0.0	-38	-86	-109	-115
	Δ^{C}_{15}	171	159	148	94	53	0.0	-31	-73	-96	-102
0.935	Δ^{R}_{15}	(102)	94	86	47	26	0.0	-12	-32	-44	-45
	Δ^{B}_{15}	94	88	81	50	31	0.0	-16	-36	-46	-49
	Δ^{C}_{15}	78	73	68	43	24	0.0	-14	-33	-43	-46
1.029	Δ^{R}_{15}	(-40)	-38	-34	-20	-13	0.0	+8	+20	+24	+26
	Δ^{B}_{15}	-44	-41	-38	-24	-14	0.0	+8	+17	+22	+23
	Δ^{C}_{15}	-39	-36	-34	-21	-12	0.0	+7	+17	+21	+22
1.120	Δ^{R}_{15}	(-188)	-174	-160	-102	-58	0.0	+32	+40	+72	+94
	Δ^{B}_{15}	-195	-182	-168	-104	-59	0.0	+34	+41	+76	+96
	Δ^{C}_{15}	-178	-166	-154	-96	-55	0.0	+32	+39	+72	+95

(30-40 °/$_{oo}$). The maximum discrepancies between these corrections and the results of Brown and Allentoft, Reeburgh, and also the formula of Cox does not exceed ± $8 \cdot 10^{-5}$, a salinity equivalent of ± 0,0032 °/$_{oo}$.

In view of its complexity, expression Δ^1_{15} is best suited for calibration and testing, but for bulk data reduction we recommend the use of Brown's formula Δ^B_{15} for wide ranges of salinity (8 to 42 °/$_{oo}$, t = -2 to 29°C) and formula Δ^2_{15} for narrow ranges of salinity (30 to 40 °/$_{oo}$, t = -2 to 31°C). In this the maximum error in calculation does not exceed $\delta\Delta^B_{15} = \pm 13 \cdot 10^{-5}$, $\delta\Delta^2_{15} = \pm 8 \cdot 10^{-5}$ of in equivalent salinity ±0,005 and ±0,003 °/$_{oo}$ respectively.

Calculation of Salinity from Conductivity Ratio

The correlation of salinity (chlorinity) of seawater with conductivity ratio is the cornerstone of the method of measuring salinity by electroconductivity. In reference (5) this connection is expressed in the form of a polynom of the fifth order for natural water, mixtures of sea and river (mineralized) waters, $S_C = f(R_{S,15,0})$ (Table 1). This relationship is proposed for calculating salinity in the range 3 to 42 °/$_{oo}$ and is the basis of the International Oceanological Tables (2).

Brown and Allentoft (4), evaporating or diluting seawater with distilled water, discovered individual dependencies of salinity on electroconductivity for waters from different regions of the world's ocean and gave an averaged expression in analog form, $S_B = f(R_{S,15,0})$ (Table 1). Cox et al measured chlorinity Cℓ °/$_{oo}$, and they calculated salinity by formula S = 1,80655 Cℓ °/$_{oo}$, while Brown and Allentoft measured salinities close to 35 °/$_{oo}$ by electroconductivity with a laboratory salinometer standardized with normal water and salinities lower and higher than this value were calculated on the basis of dilution coefficients. Such a difference of methods of obtaining samples of low salinity and ways of calculating salinity has led to a systematic divergence of values of salinity, calculated by the formulas of Cox $S_C = f(R_{S,15,0})$ and Brown $S_B = f(R_{S,15,0})$. On the figure is shown this divergence. See Figure 1,following page.

As it is nearer to real conditions, Cox's expression is recommended in the standard tables (2) and thus error $\frac{\partial S}{\partial S_C} \Delta S_C$ must be taken as the deviation from S_C of the value of salinity calculated from the expressions $S = f(R_{S,15,0})$ proposed by various authors. When using Cox's formulas the

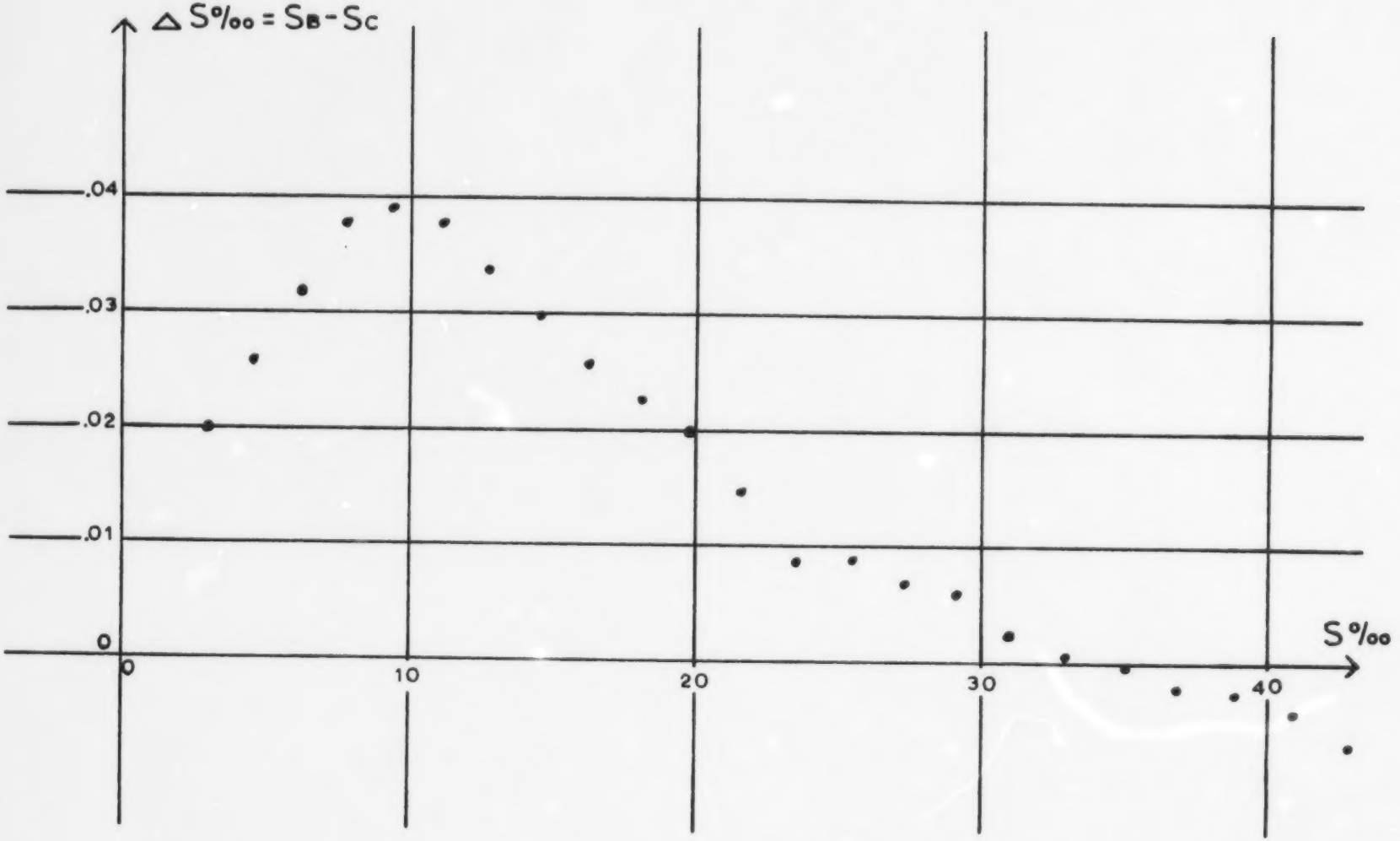

FIGURE 1: Difference between salinities calculated from Cox's formula S_C and that of Brown & Allentoft S_B.

errors of calculating salinity will equal to zero. With little loss of accuracy the formula for $S_C = f(R_{S,15,0})$ may be simplified in limited ranges of salinity.

The authors of the present paper suggest three simplified expressions, $S = f(R_{S,15,0})$, $S = f(R_{S\ 15\ 0})$ and $S = f(R_{S,15,0})$, shown in Table 1 for salinity 17 to 42 °/₀₀, 33 to 37 °/₀₀, and 7 to 18 °/₀₀ respectively. The divergence of value of salinity, calculated by formulas S_1, S_2, S_3, and S_C, within their ranges do not exceed ± 0,0013 °/₀₀, ± 0,0042 °/₀₀, and ± 0,0045 °/₀₀ respectively.

Errors in the Proposed Method of Calculating Salinity

In reference (1) the permitted values of maximum errors for each constant and formula in the scheme of calculating salinity are defined. With detailed analysis it turned out that errors of constants and formulas to be expected in practice are different from those permitted for various ranges of temperature, salinity and pressure. To evaluate the maximum error of this method of calculating salinity we have used equation (7), reference (1) for various combinations of the original formulas. It turned out that within the indicated ranges of measuring salinity, temperature and pressure, all combinations have practically identical maximum error in calculation, not exceeding 0,015 to 0,011 °/₀₀. The largest contribution to the total error is the error in the value of specific electroconductivity of normal water at 15°C and atmospheric pressure ($\Delta X_{35,15,0}$) and errors in the formula for the temperature dependence of the conductivity ratio of normal water $\Delta f(t)$ in temperature ranges -2 to 4, and 20 to 30°C.

In laboratory measurement with use of the International Oceanological Tables (2) the maximum error of calculation of salinity will be defined only as error $\delta\Delta^C_{15} \leq \pm 8 \cdot 10^{-5}$, a salinity equivalent of ± ,003 °/₀₀ with t between 10 and 30°C, S between 12 and 42 °/₀₀. To reduce the maximum error of salinity measurements from in situ, values of electroconductivity, temperature and pressure to the range 0,011 - 0,009 °/₀₀ it is essential to calibrate the samples using normal water. In this case a reduction of the total error is associated with the compensation for errors $\Delta X_{35,15,0}$ afforded by making use of a relative method of measurement.

For evaluating the accuracy of the derived formulas we will compare the value of salinity, calculated from the formulae of Perkin and Walker (10)

with those given in this paper. With allowance for differences in value of $X_{35,15,0}$ (42.923 and 42,918) for S_B and S_C, used in reference (10) and in the present paper respectively, differences in salinity values do not exceed ± 0,010 °/₀₀ in ranges of salinity 9 to 40 °/₀₀ and temperatures -2 to 20°C at atmospheric pressure.

Conclusions

1. To simplify and unify measurements made in oceanographic laboratories it is essential to accept a standard method of calculating salinity. With this goal, the following scheme is suggested: $X_{s,t,p} \rightarrow R_{s,t,0} \rightarrow R_{s,15,0} \rightarrow S$ with constants and formulas given in Table 1.

2. In using a particular set of equations it is essential to strictly maintain the constancy of units of measurement. As units of specific electroconductivity, temperature and hydrostatic pressure, the following are recommended respectively: $mho \cdot M^{-1}$, °C-IPTS-68, dbar; or $(Intn'l\ ohms)^{-1}$, °C-IPTS-48, dbar.

3. Comtemporary experimental research concerned with electroconductivity - salinity allows one to derive formulas for calculating salinity from the results of in situ measurement with maximum error 0,014 to 0,009 °/₀₀.

4. To reduce the maximum error for in situ salinity to 0,005 °/₀₀ it is essential:

a) to define more exactly ($\Delta X \leq 0{,}002\ mho \cdot m^{-1}$) the specific electroconductivity of Danish (Copenhagen) normal water with salinity exactly 35 °/₀₀ at temperature 15°C and atmospheric pressure;

b) to conduct supplementary research on temperature dependency of normal water in the ranges -2 to 4°C and 23 to 30°C at atmospheric pressure and obtain an expression for f(t) with an error of not more than $\pm\ 5 \cdot 10^{-5}$;

c) to obtain the dependence of electroconductivity of Danish (Copenhagen) normal water upon pressure in the range 0 - 10000 dbar and temperature -2 to 35 °C with error not greater than $\pm\ 5 \cdot 10^{-5}$;

d) to check the dependence of the conductivity ratio of natural oceanic seawaters on temperature and pressure (0-10000 dbar) in range of salinity 7 to 42 °/₀₀ with error not more than $\pm\ 5 \cdot 10^{-5}$.

In conclusion, the authors wish to acknowledge and thank Dr. E.R. Walker for his kind loan of materials of research, and also B.V. Meleschuka, K.N. Fedorova, P.N. Yerofeyeva for their great help in solving this problem.

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* Ed. Note: Translation accompanies this paper.